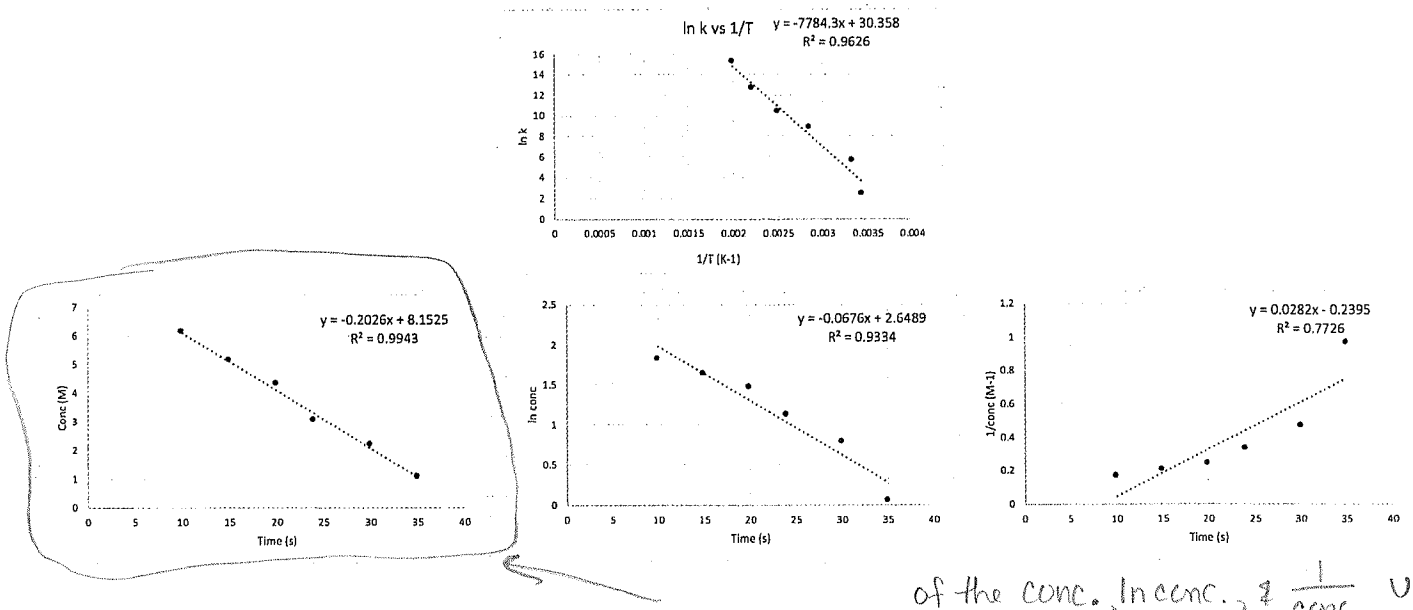
Exam 1

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! SHOW ALL WORK. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1. Use the graphs below to answer the following questions:



of the conc., ln conc., & $\frac{1}{conc.}$ vs. time graphs, the conc. vs time graph is the most linear

a.) What is the order of this reaction? Zero order

b.) What is the value of the rate constant, k? $-0.2026\ M/s$ (slope of conc vs. time graph)

c.) What is the activation energy in kJ/mol? (show work below) 64.72 kJ/mol

$E_a = (\text{slope})(-R)$ from ln k vs. $\frac{1}{T}$ graph

$= (-7784.3\text{K})(-8.314\ J/mol\,K) = 64,719\ J/mol$

or $64.72\ kJ/mol$

2. Given a 2.86M aqueous solution of KCl at 20°C, calculate:
(Assume the density of the solution is 1.08 g/mL. The molar mass of KCl is 74.5513g/mol.)

a.) The molality – assume 1 L to have 2.86 mol KCl Answer: 3.30 m

1 L = 1000 mL solution

$1000\ mL\left(\frac{1.08\ g}{1\ mL}\right) = 1080\ g$ solution $- 213.22\ g\ KCl = 866.78\ g$ solvent $= 0.86678\ kg$

$2.86\ mol\ KCl\left(\frac{74.5513\ g}{mol}\right) = 213.22\ g\ KCl$ $\quad m = \frac{mol\ solute}{kg\ solvent} = \frac{2.86\ mol}{0.86678\ kg} = 3.2996\ m$

b.) The percent by mass

$\left(\frac{g\ solute}{g\ solution}\right)100 = \left(\frac{213.22\ g\ KCl}{1080\ g\ solution}\right)100$ Answer: 19.7%

$= 19.743\%$

3. If 22.6g of $MgCl_2$ (95.211g/mol) is added to 500g of water, what is the freezing point of the solution? Use the theoretical value for the van't Hoff factor.

$\Delta T_f = i K_f m$

$i = 3$ $K_f = 1.86\ ^\circ C/m$

Answer: $-2.65\ ^\circ C$

$m = \frac{\text{mol solute}}{\text{kg solvent}} = \frac{0.23737\ mol}{0.500\ kg} = 0.474735\ m$

$\Delta T_f = (3)(1.86\ ^\circ C/m)(0.474735\ m) = 2.64902\ ^\circ C$

$22.6g\left(\frac{1\ mol}{95.211g}\right) = 0.23737\ mol$

$T_f = 0.00\ ^\circ C - 2.64902\ ^\circ C$

$= -2.64902\ ^\circ C$

4. A first order decomposition reaction was run, and it was found that half of the starting material had disappeared in 115.28s.

a.) What is the value of k for this reaction?

Answer: $6.01 \times 10^{-3}\ s^{-1}$

$t_{1/2} = \frac{0.693}{k} = 115.28\ s$

$\frac{(115.28\ s)(k)}{115.28\ s} = \frac{0.693}{115.28\ s}$ $\quad k = 6.011 \times 10^{-3}\ s^{-1}$

b.) If you started with a 2.500M solution, what concentration of material would remain after 5.00 minutes? $\times \frac{60s}{1\ min} = 300s$

Answer: 0.412M

$\ln[A] = -(6.011 \times 10^{-3}\ s^{-1})(300.\ s) + \ln[2.500]$

$\ln[A] = -1.8033 + 0.91629$

$\ln[A] = -0.88701$

$[A] = e^{-0.88701} = 0.411885\ M$

c.) If this were a zero order reaction but had the same value of k, how much material would remain after 5.00min (starting with the same 2.500M solution)?

$[A] = -(6.011 \times 10^{-3}\ s^{-1})(300.\ s) + 2.500\ M$

Answer: 0.697M

$[A] = -1.8033\ M + 2.500\ M$

$[A] = 0.6967\ M$

+273.15 = 303.15K

5. A given reaction has a k value of $0.0248 s^{-1}$ at 30.0°C. The reaction is three times faster at 50.0°C. What is the activation energy for this reaction?
+273.15 = 323.15K

a.) What is the value of k at 50.0°C?

Answer: $0.0744 s^{-1}$

$3(0.0248 s^{-1}) = 0.0744 s^{-1}$

b.) What is the activation energy for this reaction in kJ/mol?

Answer: 44700 J/mol } either
44.7 kJ/mol } ok

$$\ln\left(\frac{0.0248}{0.0744}\right) = \frac{Ea}{8.314\ J/mol\,K}\left(\frac{1}{323.15K} - \frac{1}{303.15K}\right)$$

$$8.314\ J/mol\,K \times -1.0986 = \frac{Ea}{8.314\ J/mol\,K}\left(-0.00020416\ K^{-1}\right) \times 8.314\ J/mol\,K$$

$$\frac{-9.13376\ J/mol\,K}{-0.00020416\ K^{-1}} = \frac{Ea(-0.00020416\ K^{-1})}{-0.00020416\ K^{-1}}$$

$$44738.25\ J/mol = Ea$$

6. What is the vapor pressure above 1.00kg of a 5.36m aqueous solution of fructose at 25.0°C? (Vapor pressure of pure water at 25.0°C is 23.8mmHg; molar mass of water is 18.01528g/mol.)
(intended to be 1.00kg H_2O so have 5.36 mol fructose

Answer: 21.7 mm Hg

$P_a = X_a P^\circ_a$

$X_a = \frac{\text{mol } H_2O}{\text{mol } H_2O + \text{mol fruc}}$ $\qquad 1{,}000g\left(\frac{1\,mol}{18.015288g}\right) = 55.5084\ mol\ H_2O$

$X_a = \frac{55.5084\ mol}{(55.5084\ mol + 5.36\ mol)} = \frac{55.5084\ mol}{60.8684\ mol} = 0.91194$

$P_a = (0.91194)(23.8\ mm\ Hg) = 21.704\ mm\ Hg$

7. Given the following experimental data for the reaction A + 2B → C, calculate:

Experiment	[A] (M)	[B] (M)	Rate (M/s)
1	0.20	0.10	2.78×10^3
2	0.40	0.10	2.78×10^3
3	0.20	0.20	1.11×10^4

a.) The order with respect to compound A Answer: zero

$\left(\frac{0.40}{0.20}\right)^m = \frac{2.78 \times 10^3}{2.78 \times 10^3}$

$2^m = 1 \qquad m = 0$

b.) The order with respect to compound B Answer: second

$\left(\frac{0.20}{0.10}\right)^n = \frac{1.11 \times 10^4}{2.78 \times 10^3}$

$2^n = 3.957 \approx 4 \qquad n = 2$

c.) The value of the rate constant, k (show ALL work) Answer: $2.8 \times 10^5\ M^{-1}s^{-1}$

Rate = $k[A]^0[B]^2$ $\qquad k = \frac{Rate}{[B^2]}$

Expt 1: $\frac{2.78 \times 10^3\ M/s}{[0.10M]^2} = \frac{2.78 \times 10^3 M/s}{0.01\ M^2} = 278000\ M^{-1}s^{-1}$

Expt 2: $\frac{2.78 \times 10^3 M/s}{[0.10M]^2} = 278000\ M^{-1}s^{-1}$

Expt 3: $\frac{1.11 \times 10^4 M/s}{[0.20M]^2} = \frac{1.11 \times 10^4 M/s}{0.04 M^2} = +277500\ M^{-1}s^{-1}$

$\frac{833500 M^{-1}s^{-1}}{3} = 277833\ M^{-1}s^{-1}$

$2.8 \times 10^5\ M^{-1}s^{-1}$

d.) Write the rate law for this reaction: Rate = $2.8 \times 10^5\ M^{-1}s^{-1}[B]^2$

Rate = $2.8 \times 10^5\ M^{-1}s^{-1}[A]^0[B]^2$ also ok

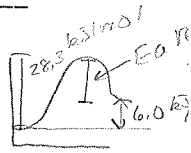
MULTIPLE CHOICE (3pts each): Write the ONE letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

1.) What is the osmotic pressure exerted by a 0.380M aqueous solution of $CaCl_2$ at 22.0°C? 1.) B
a.) 2.06 atm (b.) 27.6 atm c.) 209 atm d.) 9.21 atm

$\Pi = (3)(0.380M)(0.0821 \frac{L\,atm}{mol\,K})(295.15K) = 27.62\,atm$

2.) Based on the collision theory, which of the following is not required for a reaction to occur? 2.) D
a.) enough energy b.) correct orientation c.) collision (d.) catalyst

3.) A given **ENDOTHERMIC** reaction has an activation energy of 28.3 kJ/mol and a reaction enthalpy (ΔH) of +6.0 kJ/mol. What is the activation energy of the reverse reaction? (Sketching the energy diagram might be helpful.) 3.) A
(a.) 22.3 kJ/mol b.) 34.3 kJ/mol c.) 4.72 kJ/mol d.) 169.8 kJ/mol



4.) For the reaction 2A + 3B --> 2C, at a given instant C is being formed at a rate of 4.50M/s. At what rate is B disappearing? 4.) C
a.) 4.50 M/s b.) 3.00 M/s (c.) 6.75 M/s d.) 13.5 M/s

$4.50M/s\ C\ (\frac{3B}{2C}) = 6.75\,M/s$

5.) The rate of a reaction can often be increased by 5.) D
a.) increasing temperature b.) increasing concentration
c.) adding a catalyst (d.) all choices can be used to increase rate

6.) Which of the following describes an ustable solution out of which solute will easily precipitate? 6.) C
a.) unsaturated b.) saturated (c.) supersaturated d.) oversaturated

7.) Which type of intermolecular attractive force is used by nonpolar compounds? 7.) B
a.) dipole-dipole (b.) dispersion c.) hydrogen bond d.) ionic bond

8.) Which of the following compounds is likely to be soluble in butanol (C_4H_9-O-H)? 8.) A
(a.) CH_3-O-H b.) NaCl c.) C_6H_{12} d.) HNO_3

9.) If you want to force a lot of carbon dioxide to dissolve in water, you should 9.) B
a.) increase temperature but decrease pressure (b.) decrease temperature but increase pressur
c.) decrease temperature and pressure d.) increase temperature and pressure

10.) Select the response that best represents the theoretical value of i for $Mn(NO_3)_3$. 10.) D
a.) 2 b.) 3 c.) 1 (d.) 4